# CHARACTER OF ANALYSIS AND GENERALIZATION AS AFFECTED BY INITIAL INSTRUCTIONS IN PROBLEM SOLVING

by

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# INTRODUCTION

This investigation deals with material included under the generic term learning. In that virtually all behavior is at least in part a product of learning, its study is of considerable interest. The term learning, as used herein, is considered as a process and its study done chiefly at one descriptive level. To elaborate this statement several quotations are in order. Carr (3) states that, "An explanation of any observable phenomenon consists of stating its dependence upon some other observable or inferential condition, and this dependent relation in turn needs to be correlated with some more remote condition, and so on ad infinitum." Thus a law in psychology itself "... needs to be further explained in terms of neural mechanics, and this further explanation in turn needs to be explained in terms of physics and chemistry, etc." Lashley (13) deplores seeking causal relations in behavior by unsubstantiated "...reference to the neural substratum, and the development of elaborate neurological theories to 'explain' the phenomena in every field of psychology..." The writer is in accord with these views. Work done in psychology at one descriptive level; i.e., not embraced by underlying physiological causation, need carry with it no apology. One of the criteria of science is that it make prediction possible. Kepler was thus able to predict astronomical phenomena without the theories of Newton and Einstein.

In general terms, this investigation is concerned with an organism interacting with its environment; in more specific terms, this investigation is concerned with man in a problem solving situation. Numerous investigators, using problem solving situations suited to their own particular purposes and using both men and animals, have contributed to the field. Problem solution by animals has been studied and proved a fruitful field by such workers as Lloyd Morgan, E. L. Thorndike, D. K. Adams, W. Köhler, K. S. Lashley, C. J. Warden, R. M. Yerkes, N. R. F. Maier and many others. According to Woodworth (24), the first use of puzzles as furnishing problems for human solution was made by Lindley (14) who made a useful survey of the great variety of puzzles, linguistic and mathematical, logical and mechanical, with which people amused themselves, and found by questionnaire that the language puzzles were the most popular and the mechanical next. Ruger (19) cites early studies by investigators of learning processes such as the acquisition of telegraphy or of shorthand, of a foreign language, of skill in typewriting, and of tossing balls. Ruger himself did extensive work on problem solving using puzzles such as the Chinese ring, heart and bow, hook and eye, and a number of others. He used these puzzles as an analogue of the puzzle box previously used on animals.

While it may be said that all problem solving is governed by basic and rational principles, there is considerable difference as to the importance of the role of principles in successful solution of the problem. Judd (12), in his classical experiment in which two groups of grade school boys practiced hitting a

target under 12 inches of water, is a case in point. One group was taught the principles of refraction of light rays by water, the other was not. When the water depth was changed to four inches the group to which the principles had been taught surpassed the untutored group. Peterson (16) has shown that uniformities of behavior acquired in the solution of one problem, whether they were verbalized or not, often influenced succeeding problems. He has also shown the effect of thoroughness of learning upon transfer and that learning a problem with an understanding of the relations involved in it has a higher transfer value than learning without understanding the relations. Ruger (19), working with mechanical puzzles of the type referred to earlier, found principles to be important for transfer, especially when the subject has analyzed the similarities between a first problem and a second. Katona has worked with card tricks as puzzles for which principles have been formulated (Crafts, 7). Other investigations, using rational situations, although not exactly of the same nature, include Claparède's (4) use of pictures which the subject was called upon to explain, Duncker's (8) use of problem situations drawn from medicine and the sciences, the work of Burack (2), Graham (11), and others.

In a problem solving situation, behavior on the part of the experimenter deliberately designed to influence the subject's performance is termed guidance or tuition, and includes initial instructions. Studies have been reported in which the experimenter varied the guidance factor in a problem solving situation. This guidance factor has included the amount of tuition, the type

of tuition, and the stage at which tuition was introduced. The guidance factor in Judd's (12) experiment was the principles of refraction. Waters (22), using an apparatus and problem adapted from Peterson's (16) bead drawing experiment, investigated the influence of various modes of tuition on the rate of learning, the dependence of the efficacy of any method of tuition upon the time at which it was given, and the influence of such tuition on the ability of the subject to solve a similar problem when given no guidance; i.e., when thrown on his own initiative.[1] Waters' study relates to the present investigation and his findings will be referred to later. In another study Waters (21) investigated the influence of large amounts of manual guidance upon human maze learning. In still another study Waters and Poole (23), using the Warden maze, pattern I, and the Peterson mental maze, studied the relative retention value of stylus and mental maze habits.

For a study of the effect of guidance, tuition, or instructions on problem solving behavior a variety of problems or "structured situations," as has been noted, are available for the

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[1]Waters used six guidance methods: the Error Method (E) informing subjects of every error and requiring them to correct it; the Demonstration Method (D) with two demonstration drawings by the experimenter at the beginning of each set until the problem was mastered; the Attention Method (A) requiring subjects to call out the beads remaining after each draw; the Instruction Method (I) giving the subject information concerning the nature of the solution plus the critical number to be left after each draw; Instruction Method (II) giving the subject information concerning the nature of the solution plus the rule for determining the critical number to be left after each draw; Instruction Method (III) giving the subject information concerning the nature of the solution plus a different expression using the critical number formula.

confronting of a subject. The merits of any particular problem or puzzle vary according to the nature of the particular investigation. In the present investigation of the effect of initial instructions on problem solving behavior the disc transfer problem was selected. The earliest reports of its existence go back to antiquity.[1] The disc transfer problem was first introduced into and used in psychology by J. C. Peterson, employed by Glaze (9) and Waters (20), and first published by Joseph Peterson (17). Glaze, in a study of the age at which intelligence matures, found that the ability to solve the disc transfer problem matures before

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[1]De Parville, La Nature (Paris), 1884, part I, p. 285 quoted in W. W. R. Ball, Mathematical Recreation and Essays (Longon: Macmillan and Co.), 1931, p. 229. "De Parville gave an account of the origin of the toy which is a sufficiently pretty conceit to deserve repetition. In the great Temple at Benares, says he, beneath the dome which marks the centre of the world, rests a brass plate in which are fixed three diamond needles, each a cubit high and as thick as the body of a bee. On one of these needles, at the creation, God placed sixty-four discs of pure gold, the largest disc resting and the brass plate, and the others getting smaller and smaller up to the top one. This is the Tower of Bramah. Day and night unceasingly the priests transfer the discs from one diamond needle to another according to the fixed and immutable laws of Bramah, which require that the priest on duty must not move more than one disc at a time and that he must place this disc on a needle so that there is no smaller disc below it. When the sixty-four discs shall have been thus transferred from the needle on which at the creation God placed them to one of the other needles, tower, temple, and Brahmins alike will crumble into dust, and with a thunderclap the world will vanish.

The number of separate transfers of single discs which the Brahmins must make to effect the transfer of the tower is $2^{64}-1$, that is 18,446744,073709,551615: a number which, even if the priests never made a mistake, would require many thousands of millions of years to carry out.

the age of 15 and that up to maturity age girls excelled boys. Waters, in a study of the inheritance of intellectual ability, used five discs and a card with three circles numbered 8, 9, and 10. Peterson and Lanier (18), in studying the comparative abilities of whites and Negroes, used the numbers 1, 2, and 3 instead to designate position. Five discs were employed. The instructions to the subject in the fore-exercise were:

> You are to get these discs over to Circle 3 in the same order as that in which you see them now. You must move only one disc at a time and never place any disc upon a smaller one. You will have to use Circle 2 as a relay station. Let me show you how to do it.

Cook (5) used the disc transfer problem in a study of material and difficulty of problem solving. He considered the device particularly suited to this study in that an increase in the number of moves changes the problem quantitatively but not qualitatively, and because secondary perceptual aids are absent, each move abolishing the preceding and unfolding move by move. Cook used A, B, C to designate positions and 2, 3, and 4 discs. Experimental groups were equated using the Carnegie Mental Ability Test. The instructions given to the subject were:

> Reproduce the pattern now at A on B. Use C as a way-station when necessary. Never place a larger block upon a smaller. The problem is solved when you can reach the goal in (3, 7, 15) moves.

Cook's groups worked until they reached a criterion of one perfect trial and he recorded time and number of moves for each trial. He found that from the 7 move to the 15 move problem the increase in number of moves is 10 times, or "as the cube of the complexity ($7^3 = 343$; $15^3 = 3375$; $3375 \div 343 = 10$ approximately.)"

Groups trying 3 discs after first having learned 4 showed a significant transfer whereas those having taken the order in reverse did not. Cook (6) used the disc transfer problem for a later study of part and whole learning. Three and four discs were employed in this study and three groups were used. Group I, the control, learned to transfer 4 discs from A to B. Group II learned to move 3 discs from A to C and C to B before being given the 4 discs transfer. Group III was handled like Group II except that after completion of the second 3 discs problem the subject read the following typewritten instructions:

> Notice that the four-block (fifteen moves) problem can be broken up into the first two problems, A-C and C-B (seven plus seven equals fourteen moves) plus one move (base from A to B) by:
>
> 1. Disregarding the base and moving the upper blocks from A to C.
> 2. Then moving the base from A to B.
> 3. Finally moving the three blocks now on C to B.

For the whole versus part method Cook found only small and unreliable differences in errors, moves, time and trials.

Particular advantages possessed by the disc transfer problems include convenience of administration, ease and objectivity of scoring, absence of secondary perceptual aids, and the variety of conceptual principles which can serve as a modus operandi for successful solution. In addition, the problem is rich in mechanical and mathematical relations which may be used to test the character of comprehension and analysis resulting from various types of guidance.

## PROCEDURE

It was decided that the general plan of attack on the problem should be to take two equated groups of adults which would be referred to as the Guided and the Unguided groups. The Guided group was to receive initial instructions differing slightly from the Unguided and both groups were to be taken through 3 up to 7 discs. Following successful performance on 7 discs, both Groups were to be given the same problems and questions over the disc transfer to test their analysis of the problem and the degree to which they had grasped essential relationships.

In order to adapt the disc transfer problem to the present study, certain innovations were required and approximately 15 subjects were used in refining instructions, testing out the problem questions (Appendix D), and gaining proficiency in administration. Metal pegs instead of circles were employed and lettered A, B, and C reading counter clockwise. Discs had holes drilled in their centers large enough to permit their being placed on the pegs. To simplify taking data, letters were employed to designate position.

The apparatus used by the Unguided group consisted of the discs and board with three pegs lettered A, B, and C, respectively.

The apparatus used by the Guided group was the same as for the Unguided group except that the triangle formed by the three pegs was circumscribed by three red circular arrows. The letters

and arrows were on two white cardboard squares with holes to fit over the pegs and shaped to fit the base board. The arrows pointed clockwise on one of the squares and counter clockwise on the other. Attached to the top part of the peg board was a slip of paper with the typewritten instructions, "Move Disc #1 first and every second time thereafter in the direction indicated by the arrow." These instructions were unique to the Guided group, all other instructions being the same for both groups.[1]

Just before starting to move the discs the subjects were asked to state their moves as they made them. The smallest disc was called number one and so on in increasing order of size. Disc number one when placed on peg C would be called "1C", etc.

Two successive correct trials was the criterion which the subject was required to meet before going on to the next higher number of discs.

After successful completion of 7 discs it was customary to take a short intermission before returning to work the test questions. The experimenter placed the test questions and the peg board used by the Unguided group before the subject. The subject was also given 5 discs which had been removed from the peg and stacked in the center of the board. The experimenter read the instructions appearing at the top of the question sheet. Subjects having been instructed to work all problems in the order presented and not to skip any problem, it was possible to obtain a

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[1]For a more complete account of the method of administration as well as instructions used see Appendixes A, B, and C.

record of the time spent on each question in addition to the total time. In the early stages of setting up the experiment a time limit of 20 minutes was tried out and rejected, subjects in the experiment proper being allowed to work as long as they wished.

## RESULTS

Because of the bulky nature of the individual records of the 40 subjects, these data are summarized in Appendixes E and F rather than in this section. Subjects in the two groups are referred to by letter and number; i.e., the fifth subject in the Guided group would thus be G5 and the fifth subject in the Unguided group would be U5.

### Extra Trials

Table 1 compares the Guided with the Unguided group on the basis of the number of trials made before reaching the criterion of 2 successive perfect trials on 3, 4, 5, 6, and 7 discs.

At the 1 per cent level of confidence, computed using the standard error of the difference of the means, the results show no significant difference in mean extra trials on 3 discs, significant differences setting in at 4 discs and holding through 6 discs, then disappearing for 7 discs. Standard deviations indicate greater variability in the Unguided group. Because the mean extra trials for the Guided group were so close to zero the coefficients of variation would be misleading and therefore were not included. Beginning with 3 discs the Guided group shows a progressive reduction of extra trials corrected for minimum number of moves, whereas this trend appears only after 5 discs in the Unguided group.

Table 1. Extra trials.

| No. of discs | Mean guided | S. D. | Mean unguided | S. D. | Difference of means | Level of confidence .05 | Level of confidence .01 | Lowest subject: Guided | Lowest subject: Unguided | Highest subject: Guided | Highest subject: Unguided | Range: Guided | Range: Unguided |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | .60 | .75 | 2.10 | 2.77 | 1.50 | * | --- | 0 | 0 | 3 | 11 | 3 | 11 |
| 4 | .85 | 1.13 | 3.45 | 3.52 | 2.60 | * | * | 0 | 0 | 4 | 13 | 4 | 13 |
| 5 | 1.30 | 1.42 | 8.95 | 8.60 | 7.65 | * | * | 0 | 0 | 5 | 36 | 5 | 36 |
| 6 | .40 | .68 | 5.10 | 4.10 | 4.70 | * | * | 0 | 0 | 2 | 14 | 2 | 14 |
| 7 | .10 | .31 | 3.40 | 5.36 | 3.30 | * | --- | 0 | 0 | 1 | 19 | 1 | 19 |
| all | 3.25 | 2.67 | 23.00 | 17.55 | 19.75 | * | * | 1 | 4 | 9 | 81 | 8 | 77 |

| | Mean extra trials corrected for minimum no. of moves** Guided | Unguided |
|---|---|---|
| 3 | 86. | 300. |
| 4 | 57. | 230. |
| 5 | 42. | 289. |
| 6 | 6.3 | 81. |
| 7 | .79 | 27. |
| all | --- | --- |

*Difference of means significant at level indicated.
**Mean extra trials for 3, 4, 5, 6, and 7 discs divided by .007, .015, .031, .063, and .127 respectively. (The minimum number of moves required to transfer 3, 4, 5, 6, and 7 discs 7, 15, 31, 63, and 127 respectively).

## Time on Trials

Table 2 compares the Guided with the Unguided group on the basis of the time, in seconds, spent in reaching the criterion of two successive perfect trials on 3, 4, 5, 6, and 7 discs.

At both levels of confidence, computed using the standard error of the difference of the means, the results show no significant difference in time on 3 discs, significant differences setting in at 4 discs and holding through 6 discs, then disappearing for 7 discs. Standard deviations and coefficients of variation show greater variability in the Unguided group. Beginning with 5 discs both groups show a progressive economy of time corrected for minimum number of moves. The range of the Unguided group is consistently greater than the range of the Guided group. The individual records show several fairly distinct trends. For a given number of discs, successive trials tended to show a progressive economy of time and progressive uniformity in pattern of movement of the discs. When these uniform patterns of movement corresponded to the disc transfer problem's correct solution the last two trials were the shortest trials. Sometimes, however, subjects would standardize a false approach, i.e.; one requiring more than the minimum number of moves. Time on trials would increase again when the subject, realizing he was employing unworkable concepts, tried to break out of his old pattern and find the correct solution. Some subjects repeated this procedure several times before finding the correct solution and their time on trials rose and fell as the cycle was repeated.

Table 2. Time on trials.

| No. of discs | Mean guided | S. D. guided | Mean unguided | S. D. unguided | Difference of means | Level of confidence .05 | Level of confidence .01 | Lowest subject: Guided | Lowest subject: Unguided | Highest subject: Guided | Highest subject: Unguided | Range: Guided | Range: Unguided |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 92.0 | 52.5 | 205.2 | 276.7 | 113.2 | --- | --- | 24 | 29 | 222 | 1311 | 198 | 1282 |
| 4 | 223.3 | 113.4 | 592.0 | 131.2 | 368.8 | * | * | 62 | 93 | 461 | 1395 | 399 | 1302 |
| 5 | 440.1 | 189.2 | 2046.5 | 1662.3 | 1606.4 | * | * | 237 | 320 | 852 | 6336 | 615 | 6216 |
| 6 | 489.0 | 204.9 | 2127.6 | 1508.7 | 1638.6 | * | * | 283 | 371 | 1231 | 5740 | 948 | 5369 |
| 7 | 752.0 | 233.1 | 2449.4 | 4021.3 | 1697.4 | --- | --- | 446 | 553 | 1583 | 19169 | 1137 | 18616 |
| all | 1996.4 | 573.3 | 7595.7 | 6021.7 | 5599.3 | * | * | 1133 | 3058 | 3877 | 30657 | 2744 | 27599 |

| No. of discs | Coefficient of variation: Guided | Coefficient of variation: Unguided | Mean time on trials corrected for minimum no. of moves**: Guided | Mean time on trials corrected for minimum no. of moves**: Unguided |
|---|---|---|---|---|
| 3 | 57 | 135 | 13.2 | 29. |
| 4 | 51 | 22 | 14.9 | 39. |
| 5 | 43 | 81 | 14.2 | 66. |
| 6 | 42 | 71 | 7.8 | 34. |
| 7 | 31 | 164 | 5.9 | 20. |

*Difference of means significant at level indicated.
**Mean time on trials for 3, 4, 5, 6, and 7 discs divided by 7, 15, 31, 63 and 127 respectively. (The minimum number of moves required to transfer 3, 4, 5, 6, and 7 discs is 7, 15, 31, 63, and 127 respectively).

## Total Moves

Table 3 compares the Guided with the Unguided group on the basis of total moves made in reaching the criterion of two successive perfect trials on 3, 4, 5, 6, and 7 discs.

At the 1 per cent level of confidence, computed using the standard error of the difference of the means, the results show no significant difference in the average number of moves on 3 discs, significant differences setting in at 4 discs and holding through 6 discs, then disappearing for 7 discs. Standard deviations and coefficients of variation show greater variability in the Unguided group. The range of the Unguided group is consistently greater than the range of the Guided group. The Unguided group shows a successive reduction of total moves beginning with 5 discs, whereas no consistency appears in the Guided group. Individual records manifest a trend noted in the case of time on trials; i.e., a progressive reduction of moves and a progressively uniform movement pattern which, when incorrect, had to be changed as the subject searched for the correct solution and which frequently increased the number of moves. This, however, was not always the case, some subjects having been able to proceed directly from an incorrect set to the correct one.

Table 3. Total moves.

| No. of discs | Mean guided | S. D. guided | Mean unguided | S. D. unguided | Difference of means | Level of confidence .05 | Level of confidence .01 | Lowest subject: Guided | Lowest subject: Unguided | Highest subject: Guided | Highest subject: Unguided | Range: Guided | Range: Unguided |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 19.15 | 7.42 | 35.10 | 26.12 | 15.95 | * | --- | 14 | 14 | 44 | 115 | 30 | 101 |
| 4 | 44.40 | 19.35 | 107.25 | 72.45 | 62.85 | * | * | 30 | 30 | 101 | 311 | 71 | 281 |
| 5 | 105.05 | 48.09 | 478.05 | 426.39 | 373.00 | * | * | 62 | 62 | 238 | 1803 | 126 | 1741 |
| 6 | 148.65 | 43.48 | 531.80 | 352.77 | 383.15 | * | * | 126 | 126 | 262 | 1390 | 136 | 1264 |
| 7 | 280.15 | 53.66 | 612.80 | 666.00 | 332.65 | * | --- | 254 | 254 | 387 | 3208 | 133 | 2954 |
| all | 597.40 | 111.96 | 1760.00 | 400.64 | 1162.60 | * | * | 496 | 697 | 938 | 6437 | 442 | 5740 |

| No. of discs | Coefficient of variation: Guided | Coefficient of variation: Unguided | Mean total moves corrected for minimum no. of moves: Guided | Mean total moves corrected for minimum no. of moves: Unguided |
|---|---|---|---|---|
| 3 | 39 | 75 | 2.7 | 5.0 |
| 4 | 44 | 68 | 3.0 | 7.1 |
| 5 | 46 | 89 | 3.4 | 15.4 |
| 6 | 30 | 66 | 2.3 | 8.4 |
| 7 | 19 | 109 | 2.2 | 4.8 |
| all | 19 | 23 | --- | --- |

*Difference of means significant at level indicated.

** Mean total moves for 3, 4, 5, 6, and 7 discs divided by 7, 15, 31, 63, and 127 respectively. (The minimum number of moves required to transfer 3, 4, 5, 6, and 7 discs is 7, 15, 31, 63, and 127 respectively).

Average Time per Move

Table 4 compares the Guided with the Unguided group on the basis of average time per move, in seconds, on the various trials.

At both levels of confidence, computed using the standard error of the difference of the means, the results show no significant differences on 3, 4, and 5 discs. The Guided group shows a general reduction of average time per move, whereas the Unguided group's average rises sharply from 3 to 4 discs. The Unguided group, for 4 discs, had to determine whether to make their first move to peg C or to peg B and this decision seems to be reflected by the increased time. Some subjects announced their belief that the first move was always to Peg C and registered amazement when they met with failure on 4 discs. Being thus stymied, subjects were sometimes inclined toward making slow and exploratory moves which increased the average time per move. Individual records for several subjects show 30 seconds elapsing at the beginning of a trial while the subject studied the situation. Guided subjects were not faced with this decision as to their move, although they had to adapt to a reversal in direction of the arrow and their average time was the same for 3 and 4 discs. Many unguided subjects had confirmed their concept regarding alternation of the first move for successive numbers of discs and their rate of disc manipulation increased for 6 and 7 discs. For 6 discs the difference of the means is 1.09 seconds. This increase in the rate of disc manipulation represents a gain of 1.15 for the Guided group but only a .54 second gain for the Unguided. The

Table 4. Average time per move.

| No. of discs | Mean guided | S. D. | Mean unguided | S. D. | Difference of means | Level confidence .05 | .01 | Lowest subject: Guided | Lowest subject: Unguided | Highest subject: Guided | Highest subject: Unguided | Range: Guided | Range: Unguided |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 4.99 | 2.75 | 4.51 | 1.89 | .48 | --- | --- | 1.71 | 2.07 | 12.28 | 11.40 | 10.57 | 9.33 |
| 4 | 4.99 | 1.50 | 5.79 | 2.29 | .80 | --- | --- | 2.07 | 3.10 | 7.43 | 12.14 | 5.36 | 9.04 |
| 5 | 4.43 | 1.51 | 4.91 | 2.11 | .48 | --- | --- | 2.27 | 2.81 | 7.89 | 12.95 | 5.62 | 10.14 |
| 6 | 3.28 | .74 | 4.37 | 1.04 | 1.09 | * | * | 2.25 | 2.51 | 4.92 | 6.14 | 2.67 | 3.63 |
| 7 | 2.69 | .59 | 3.50 | 1.03 | .81 | * | * | 1.75 | 2.32 | 4.09 | 5.97 | 2.34 | 3.65 |
| all | 3.34 | .68 | 4.33 | .94 | .99 | * | * | 2.06 | 3.12 | 4.72 | 5.28 | 2.66 | 2.16 |

| No. of discs | Coefficient of variation: Guided | Coefficient of variation: Unguided |
|---|---|---|
| 3 | 55 | 42 |
| 4 | 30 | 40 |
| 5 | 34 | 43 |
| 6 | 23 | 24 |
| 7 | 22 | 29 |
| all | 20 | 22 |

*Difference of mean significant at level indicated.

biggest rate increase for the Guided group was made in going from the 5 disc problem to the 6 disc problem, whereas the Unguided group registered their biggest increase in going from 6 to 7 discs. Individual records show that only 3 subjects in the Guided group moved 6 discs at an average rate of 4 seconds per move or more, while 13 unguided subjects moved at a rate of 4 seconds per move or more; on 7 discs only 1 guided and 4 unguided subjects moved this slowly. The data show slightly greater variability in the Unguided group at all levels.

### Average Time per Trial

Table 5 compares the Guided with the Unguided group on the basis of average time per trial, in seconds, for 3, 4, 5, 6, and 7 discs. Means and indices of variation were not computed for pooled trials because they would have no meaning.

The largest difference in the means is found for 6 discs, one of the trends cited earlier for mean time per move on 6 discs. Both average time per trial and average time per move contain the same variable; i.e., time, and the factors producing the two situations were quite similar. The groups show no significant difference on 7 discs. Beginning with 4 discs both groups show a progressive reduction in mean time per trial corrected for minimum number of moves. Consistently greater variability is found in the Unguided group.

Table 5. Average time per trial.

| No. of discs | Mean guided | S. D. | Mean unguided | S. D. | Difference of means | Leval of confidence .05 | .01 | Lowest subject: Guided | Lowest subject: Unguided | Highest subject: Guided | Highest subject: Unguided | Range: Guided | Range: Unguided |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 35.2 | 17.0 | 41.4 | 20.5 | 6.2 | --- | --- | 12.0 | 14.5 | 74.0 | 100.8 | 62.0 | 86.3 |
| 4 | 77.0 | 23.3 | 111.7 | 47.1 | 34.7 | * | --- | 31.0 | 51.7 | 115.7 | 209.5 | 84.7 | 157.8 |
| 5 | 139.5 | 46.9 | 200.8 | 99.3 | 61.3 | * | --- | 71.5 | 118.3 | 244.5 | 580.7 | 173.0 | 462.4 |
| 6 | 203.2 | 46.2 | 315.1 | 107.8 | 111.9 | * | * | 141.5 | 180.0 | 307.7 | 643.6 | 166.2 | 463.6 |
| 7 | 361.4 | 116.4 | 456.6 | 173.5 | 95.1 | * | --- | 223.0 | 272.8 | 781.5 | 1008.9 | 568.5 | 736.1 |

| | Coefficient of variation: Guided | Coefficient of variation: Unguided | Mean time per trial corrected for minimum no. of moves**: Guided | Mean time per trial corrected for minimum no. of moves**: Unguided |
|---|---|---|---|---|
| 3 | 48 | 59 | 5.0 | 5.9 |
| 4 | 30 | 42 | 5.1 | 7.4 |
| 5 | 34 | 49 | 4.5 | 6.5 |
| 6 | 23 | 34 | 3.2 | 5.0 |
| 7 | 32 | 38 | 2.8 | 3.6 |
| all | -- | -- | --- | --- |

*Difference of means significant at level indicated.
**Mean time for trials on 3, 4, 5, 6, and 7 discs divided by 7, 15, 31, 63, and 127 respectively. (The minimum number of moves required to transfer 3, 4, 5, 6, and 7 discs is 7, 15, 31, 63, and 127 respectively).

Time on Problem Questions

Table 6 compares the Guided with the Unguided group on the basis of the average time, in seconds, spent working the problem questions. The subjects were allowed to work on the questions for as long a time as they wished. The task was considered completed when the subject felt he had answered all the questions to the best of his ability; the subject was given neither guidance nor coaching, nor was he informed as to whether his answers were right or wrong.

Table 6. Time on problem questions.

| Mean guided | S. D. | Mean unguided | S. D. | Difference of means |
|---|---|---|---|---|
| 2053 | 775.5 | 1725 | 582 | 328* |

*Not significant.

The Guided group required approximately one-fifth more time to work the problem questions although the difference was not significant at levels calculated. The Guided group shows more variation than the Unguided group.

Errors on Problem Questions

Table 7 compares the Guided with the Unguided group on the basis of the average number of errors made on the problem questions.

Table 7. Errors on problem questions.

| Guided | Unguided | Mean guided | S. D. | Mean unguided | S. D. | Difference of means |
|---|---|---|---|---|---|---|
| 111 | 75 | 5.55 | 3.58 | 3.75 | 2.35 | 1.80* |

*Significant at 6 per cent level of confidence.

The Guided group made errors on the problem questions totaling 111 as compared with 75 for the Unguided group, a difference significant at the 6 per cent level of confidence. Standard deviations indicate greater variability in the Guided group, reversing the trend noted for performance on the peg board. The larger fund of concepts possessed by the Unguided group proved helpful on the problem questions. The nature of the guidance was such as to shield the Guided group and prevent their acquiring some of the concepts essential to correct solution of the problem questions.

## General

A record was kept to show how frequently subjects, while working the problem question, used the discs to check their thinking and help find the answers. Although this practice was not instituted until after the experiment was underway, available records indicate that the Guided group was forced to rely more heavily on the peg board.

The guided subjects moved the larger numbers of discs in a rather mechanical manner whereas the unguided subjects appeared more alert to the actual relations involved in the moves and seemed to be aware of attaining intermediate goals. It was certainly

true that the unguided subjects had to rely more heavily on their own iniative.

Upon being presented with the problem questions a typical comment made by the Guided group was, "Gosh! If I'd known I was going to be asked these questions, I would have been more observant." The Unguided group reacted with generally greater confidence.

One subject exhibiting neurotic symptoms was dropped before completion of the series and another subject substituted; all subjects, with this exception, completed the experiment.

Scatter diagrams for certain of the variables, using data from the Unguided group, were plotted. Subjects taking more time on the discs tended to make more errors on the problem questions. Subjects taking more moves; i.e., making more errors, tended to make more errors on the problem questions. Subjects requiring greater numbers of trials on the discs also tended to make more errors on the problem questions. A trend toward a negative relationship between total moves on discs and total problem time suggests several possibilities, or perhaps a combination. It is possible that subjects who had worked a long time on the discs were eager to finish the problems and leave. The possibility that subjects who took the larger numbers of moves had achieved greater mastery must be rejected upon considering that these subjects made more errors on the problem questions. There is the possibility that the brighter subjects, transferring the discs in fewer moves, realized that the problem questions were difficult and consequently spent more time trying to solve them. There is the possibility that the brighter subjects adopted a faster pace on the disc transfers as

irrelevant considerations dropped out and routine observations and check-ups evolved.

The performance of the Guided group, being generally more uniform, exhibited no significant trends.

## DISCUSSION

### General Effects of Guidance

A trend was noted in the results wherein no differences, at the 1 per cent level of confidence, were shown between the groups on mean extra trials, mean time on trials, and mean total moves for the 3 disc problem. Differences found for 4 through 6 discs disappeared for 7 discs. The possibility that a few individuals, deviating appreciably from the mean, could have caused the similarities and differences observed must be ruled out when it is considered that significance was calculated using the means and standard deviations. The standard deviations, based on square of numbers, is much more sensitive to extremes in dispersion than the means.

The most likely explanation seems to be that the groups did not exhibit differences on 3 discs because both groups were in an unfamiliar situation. Although the means for the Unguided group were larger than for the Guided group, the difference was not significant since the difficulty of adjusting to the task by the Guided group was offset by the relative simplicity of the 3 disc transfer for the Unguided group. The lack of significant difference for 7 discs suggests that at this stage the Unguided group

had pretty well learned the solution of the disc transfer problem and thus tended to equal the Guided group. Belief that the Unguided group, upon reaching 7 discs, had become proficient in transferring the discs to designated pegs is supported by individual records, performance on the problem questions, and general evidence in the literature indicating that college level adults, when given sufficient time, are capable of learning the disc transfer problem.

When and under what circumstances did insightful behavior tend to manifest itself? Where did the largest strides in learning tend to be observed? The question can be better treated using the records of the unguided subjects, so little variability having been found in the Guided group. A study of individual records shows that one subject, U16, after a single trial on 4 discs, was able to complete the remainder of the problems with very little effort, as indicated by extra moves and trials. His 1 extra trial on 6 discs and 2 extra trials on 7 discs were caused by careless and not fundamental errors. For slightly less than half of the subjects, great strides in learning had been taken before the completion of the 5 disc transfer. Five discs seemed to satisfy observant subjects as to the alternation of the first move, from C to B and back again to C, required for 3, 4, and 5 discs respectively. A few stragglers seemed still in doubt after the completion of 7 discs. The record of subject U18 is of interest since this subject was the only one in the Unguided group to make a perfect score on the problem questions. This subject required more extra trials on 6 discs than any other subject and was second highest in terms of total time on all discs.

The effect of guidance upon the time required to attain the goal of the disc transfer problem was such as to reduce learning time as well as to reduce variability of learning time within the group. Guidance, of the sort used, had an adverse influence on transfer and mastery. Formal education, it may be mentioned, speeds learning time and causes greater uniformity. Is guidance in education undesirable? The instructions given the Unguided group had an influence on the group's performance just as surely as the other set of instructions influenced the Guided group. In reality, both groups received guidance in that they both received instructions. The question, therefore, is not "to guide or not to guide," but what type of guidance will produce the desired result.

In this study, subjects in the Guided group appeared to use their guidance as a "crutch" in that they were conveyed along by the guidance without an appreciation of vital relations inherent to the problem. Accordingly they made a poorer showing when they reached the problem questions which had been designed to measure relations inherent in the problem, degrees of analysis, and levels of mastery.

The findings of this study generally support those of Alonzo (1), based on maze learning by rats, and those of Waters (21), based on human maze learning, that the efficacy of initial guidance depends on its being given in large amounts. They also support Waters' findings that guidance operates to reduce the variability of guided groups in terms of trials and time. The results of the problem questions support Carr's (3) statement that too great a prevention of errors retards the process of learning. The findings

agree with Katona's statement that a "principle" must be actively derived and understood by the learner if it is to have much utility for him (Crafts, 7). The findings agree with Cook's (6) suggestion that verbal guidance may be of considerable assistance in the solution of the disc transfer problem.

Many subjects in the Unguided group in this experiment exhibited analyses observed by Ruger (19). 1. Locus analysis. The subject first noticed especially crucial parts of the problem; i.e., the first move, and was thus able to eliminate superfluous experiments on following trials. 2. Analysis after the act. Many subjects could not see ahead to the solution but noticed how success occurred as or after it occurred. 3. Stages of analysis. After a subject had grasped the basic relationships there was still opportunity for analysis of details and such analysis led to greater skill and mastery, especially as measured by the problem questions.

## Adequacy of Criteria

In this study, many subjects, having once made a perfect trial, went on to make a long series of incorrect trials before grasping the problems and attaining the criterion of 2 successive perfect trials. Cook's (5) criterion of a single perfect trial appears to have been inadequate. Even 3 successive correct trials may not be excessive. Findings made here justify the use of caution when dealing with criteria assuming equal minimum levels of mastery in learning.

## Transfer

The nature of this study was such that it afforded several particularly good opportunities for noting transfer. Transfer is generally considered as being the influence of prior learning upon the learning of new material. The Guided group exhibited negative transfer in going from the disc transfer problems to the problem questions. The guidance was such as to have an adverse influence on the formation of concepts and the noting of relationships which were needed when the subjects dealt with the new material given in the problem questions. Some of the guided subjects, after completing the disc transfer problems through 7 discs, still did not know what their first move had to be in order to transfer 3 discs from one peg to another. This was observed when some of the subjects, while working the problem questions, attempted to move the discs. The unguided subjects rarely had this difficulty.

For transfer of training from lower to successively higher numbers of discs the Unguided group furnishes more evidence than the Guided. The larger disc transfer problems; i.e., those involving 4 or more discs, may all be broken down into patterns based on the transfer of 3 discs. Subjects were showing transfer when they employed this concept. The 7 disc transfer problem provided numerous situations in which to observe transfer of previous learning, because the 7 disc transfer problem involved transferring 6 discs 2 times, 5 discs 4 times, 4 discs 8 times, and 3 discs 16 times. Some subjects, even on the 7 disc problem,

were still making errors in transferring 3 and 4 discs. Although records of moves made by the subjects would undoubtedly serve to increase the adequacy of this discussion, limitations as to time and space render this impossible. The findings made in this investigation, that concepts and general principles are of great importance in their influence on transfer of training, are in agreement with the findings of other investigators.

## Methods of Solution

Throughout this experiment, subjects were forced to seek the solutions for series of problems. How can their problem solving behavior best be described? The subjects is this experiment exhibited the sort of behavior that has been submitted as evidence for both insight and trial and error. It is pretty well accepted that trial and error does not imply completely random behavior. All moves made by the Unguided subjects appeared to have had some purpose, such as to determine the consequences of a given step, or to verify a concept or "insight". These concepts or "insights" appeared to vary in nature: they were sometimes false and misleading, they were sometimes incompletely formulated, sometimes they were forgotten, and sometimes they were incorrectly recalled. These phenomena have been observed by a number of other investigators.

The gestalt school of psychology does not deny that trial and error occurs, but only that it solves the problem. In this experiment, a number of examples were noted where subjects exhibited

behavior which seemed to meet the gestalt criteria of insight. It is felt, however, that all of these cases could be described as the product of trial and error and transfer. The writer believes that if insight does exist, it merges with trial and error in what appears to be a continuous series of events, as noted by McGeoch (15).

## Suggestions for Further Study

The disc transfer problem has been used by various investigators in studies of intelligence and the results of the present study suggest further attempts be made to better adapt the problem to this purpose. A variety of data may be obtained: total time, average time for trials and moves, number of moves and errors, number of moves required to correct errors, and so on. Most of these measurements will have to be weighted and modified. If, for example, an error is made on 7 discs and another trial be required, even a perfect trial would involve 127 moves. An extra trial on 3 discs involves only 7 moves. Appropriate weights are needed to remedy situations like these. The disc transfer problem is such as to facilitate observations concerning some of the "higher" types of intelligence; i.e., ability to generalize at abstract levels, and ability to perceive relations and to apply these relations to new material.

The findings made in this study suggest that criteria of learning and mastery may easily be misleading and inadequate, and it is likely that cases may be found where earlier experiments might be profitably repeated.

## SUMMARY AND CONCLUSIONS

A study of guidance, using the disc transfer problem, instituted with initial instructions, was made using two groups of 20 equated college level adults which were referred to as the Guided and Unguided groups. The Guided group manipulated the discs in less time, made fewer extra moves and fewer errors, and showed less variability, but failed to show as much transfer, as measured by problems and questions, as the Unguided group. The Unguided group required more time and extra trials, made more extra moves, and manipulated the discs more slowly than the Guided group, but showed a higher degree of mastery and transfer.

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## APPENDIX A

### Instructions for Non-Guided Solution

Your problem is to place these discs on Peg C. When you are through they will look like this (E demonstrates by lifting off all the discs together and placing them in the final position). Move only one disc at a time...the one on top. Never place a disc upon another that is smaller than itself. When I say begin, place the discs on Peg C in the fewest moves possible. Take all the time you need. Speed is not important, but I will record your time.

As soon as O finishes, E places the discs (all at once) back on Peg A and says: "Do it again."

Immediately after two successive correct trials, with Peg C as the goal, E adds a fourth disc and places them back on Peg A saying: "We will now add a fourth disc. Place them on Peg C."

Immediately after two successive correct trials, E adds a fifth disc and places the discs back on Peg A saying: "We will now add a fifth disc. Place them on Peg C."

Immediately after two successive correct trials, E adds a sixth disc and places the discs back on Peg A saying: "We will now add a sixth disc. Place them on Peg C."

Immediately after two successive correct trials, E adds a seventh disc and places the discs back on Peg A saying: "We will now add a seventh disc. Place them on Peg C."

If more sessions than one are required, arrange for the next session and ask O to refrain from thinking or talking about the problem in the meantime. Explain why.

As soon as O finishes the 7 disc problem, give him the problem sheet, read the directions with him and say: "You may begin."

Ask O not to discuss the experiment with others. Explain why.

## APPENDIX B

### Instructions for Guided Solution

Your problem is to place these discs on Peg C. When you are through they will look like this (E demonstrates by lifting off all the discs together and placing them in the final position). Move only one disc at a time...the one on top. Never place a disc upon another that is smaller than itself. When I say begin, place the discs on Peg C in the fewest moves possible. Take all the time you need. Speed is not important, but I will record your time. This is how you do it. Move Disc #1 first and every second time thereafter in the direction indicated by the arrow.

As soon as O finishes, E places the discs (all at once) back on Peg A and says: "Do it again."

Immediately after two successive correct trials with Peg C as the goal, E adds a fourth disc and places them back on Peg A saying: "We will now add a fourth disc. Place them on Peg C. Move Disc #1 first and every second time thereafter in the direction indicated by the arrow."

Immediately after two successive correct trials, E adds a fifth disc and places the discs back on Peg A saying: "We will now add a fifth disc. Place them on Peg C."

Immediately after two successive correct trials, E adds a sixth disc and places the discs back on Peg A saying: "We will now add a sixth disc. Place them on Peg C."

Immediately after two successive correct trials, E adds a seventh disc and places the discs back on Peg A saying: "We will now add a seventh disc. Place them on Peg C."

If more sessions than one are required, arrange for the next session and ask O to refrain from thinking or talking about the problem in the meantime. Explain why.

As soon as O finishes the 7 disc problem, give him the problem sheet, read the directions with him and say: "You may begin."

Ask O not to discuss the experiment with others. Explain why.

## APPENDIX C

### General Instructions for the Disc Transfer Experiment

1. Information sheet. The session is begun by giving this to O to fill out. Rapport should be established in the process. Essential information which must be obtained: name, address and/or telephone number, and classification (for determining total college time). To put subjects at ease it is sometimes necessary to assure them that their names will not appear in any final write-up.

2. Peg board. When the instruction sheet has been completed and rapport established, the peg board is placed before O and administered according to directions. Once begun, trials should be completed. It sometimes happens that a subject makes a mistake and asks to start all over again. Such action invalidates results and this can be explained to O. Subjects are not permitted to make any uncounted exploratory moves. Only one disc may be off the pegs at any one time. As soon as a disc is released from grasp, as with chess, it is counted as a move. In the guided solution O is corrected immediately after his first wrong move and instructed to check his instructions. Move or moves required to "get back on the track" are recorded. After successful trials on 3, 4, and five discs E says: "Perfect! You did that in the minimum which is (7, 15 or 31) moves." For 6 and 7 discs E informs O that his moves were at a minimum but does not specify. For imperfect trials E says: "You made some extra moves" but never specifies how many.

3. Problem questions. After two consecutive correct trials on 7 discs E says, "Now I want you to answer some questions about the work you have done." He then places the question sheet, pencil, and scratch paper before O and reads through the instructions with him. Just before saying, "You may begin," E casually mentions to O that he (E) will be recording some data but that O should not pay any attention to him. E records time for each of the 22 questions as soon as the answer has been recorded. This requires paying close attention to O, but it has been found that O is usually too preoccupied to be bothered by E. O is allowed as much time as he wants to work on the problems but the average time spent runs under 30 minutes, the maximum having been 45 minutes.

4. A. E. D. Test of Verbal Aptitude. Administer at some session other than the disc transfer session. For equating groups, use scores made by subjects during 25 minute performances.

## APPENDIX D

### Problems for Disc Transfer Experiment

Instructions-- Read each of the following problems carefully and solve as many of them as you can in the next twenty minutes. For some of the problems the correct solution is listed among the optional answers, in which case you should indicate your answer by underlining; the remainder are to be answered by filling in the blank. Work all problems in the order in which they are presented. Do not skip any problem. You may use the discs and pegboard to check your thinking on the simpler problems. This experiment will be underway during the next month and you are asked to refrain from discussing this experiment with others because some of them will also be serving as subjects.

1. In transferring 3 discs from Peg A to Peg C Disc #1 moves in a (a) clockwise (b) counter clockwise direction.
2. In transferring 3 discs from Peg A to Peg B Disc #1 moves in a (a) clockwise (b) counter clockwise direction.
3. In transferring 4 discs from Peg A to Peg C Disc #2 moves in a (a) clockwise (b) counter clockwise direction.
4. In transferring 4 discs from Peg A to Peg C Disc #3 moves in a (a) clockwise (b) counter clockwise direction.
5. In transferring 5 discs from Peg A to Peg C Disc #4 moves in a (a) clockwise (b) counter clockwise direction.
6. In transferring 7 discs from Peg A to Peg C Disc #5 moves in a (a) clockwise (b) counter clockwise direction.
7. Even numbered discs move in the (a) same (b) opposite direction as odd discs.
8. In transferring 3 discs from Peg A to Peg C the first move is to Peg___.
9. In transferring 4 discs from Peg A to Peg C the first move is to Peg ___.
10. In transferring 5 discs from Peg A to Peg C the first move is to Peg ___.
11. In transferring 6 discs from Peg A to Peg C the first move is to Peg ___.
12. State the general rule for determining what the first move is to be for transferring any number of discs from Peg A to Peg C.

| | No. Discs | Moves | No. of Moves Required | | | | |
|---|---|---|---|---|---|---|---|
| 13. | 3 | ___ | (a) 3 | (b) 5 | (c) 7 | (d) 9 | (e) 11 |
| 14. | 4 | ___ | (a) 9 | (b) 11 | (c) 13 | (d) 15 | (e) 17 |
| 15. | 5 | ___ | (a) 21 | (b) 27 | (c) 31 | (d) 37 | (e) 41 |
| 16. | 6 | ___ | (a) 51 | (b) 63 | (c) 72 | (d) 81 | (e) 99 |
| 17. | n | | (a) $n^2-1$ | (b) $2^n-1$ | (c) $n^2+n-1$ | (d) $2n+1$ | (e) $\frac{n^2-n}{2}$ |

18. In transferring 5 discs the total number of moves made by the various discs is:
Disc #5 ___ moves
Disc #4 ___ moves
Disc #3 ___ moves
Disc #2 ___ moves
Disc #1 ___ moves

19. In transferring 5 discs the 21st move is made by disc No. (a) 1 (b) 2 (c) 3 (d) 4 (e)5.

20. In transferring 5 discs from Peg A to Peg C Disc #5 moves on the (a) 14th (b) 15th (c) 16th (d) 17th (e) 18th move.

21. In transferring 7 discs the 96th move is made by Disc No. (a) 2 (b) 3 (c) 4 (d) 5 (e) 6.

22. The above move is made from Peg: (a) A to B (b) A to C (c) B to C (d) C to A (e) B to A.

APPENDIX E

Summary of Individual Records of Unguided Group

| Unguided Subject | A.E.D.* Score | Errors on Questions | Extra Trials on Discs 3 | 4 | 5 | 6 | 7 | all |
|---|---|---|---|---|---|---|---|---|
| 1 | 50 | 2 | 0 | 2 | 7 | 4 | 0 | 13 |
| 2 | 53 | 3 | 3 | 0 | 5 | 0 | 0 | 8 |
| 3 | 53 | 2 | 2 | 2 | 3 | 0 | 2 | 9 |
| 4 | 55 | 3 | 1 | 2 | 7 | 7 | 0 | 17 |
| 5 | 47 | 8 | 6 | 4 | 24 | 0 | 1 | 35 |
| 6 | 53 | 4 | 2 | 9 | 7 | 7 | 1 | 26 |
| 7 | 50 | 5 | 11 | 1 | 5 | 5 | 2 | 24 |
| 8 | 38 | 6 | 1 | 1 | 12 | 10 | 6 | 30 |
| 9 | 47 | 2 | 2 | 0 | 5 | 1 | 1 | 9 |
| 10 | 47 | 1 | 0 | 5 | 0 | 1 | 1 | 7 |
| 11 | 55 | 3 | 0 | 7 | 15 | 8 | 2 | 32 |
| 12 | 50 | 4 | 0 | 2 | 4 | 3 | 1 | 10 |
| 13 | 47 | 10 | 0 | 2 | 9 | 7 | 7 | 25 |
| 14 | 52 | 4 | 3 | 6 | 4 | 9 | 0 | 22 |
| 15 | 43 | 3 | 0 | 3 | 10 | 6 | 1 | 20 |
| 16 | 53 | 6 | 0 | 1 | 0 | 1 | 2 | 4 |
| 17 | 44 | 2 | 2 | 2 | 2 | 1 | 0 | 7 |
| 18 | 41 | 0 | 2 | 1 | 8 | 14 | 2 | 27 |
| 19 | 27 | 3 | 6 | 13 | 36 | 9 | 17 | 81 |
| 20 | 43 | 4 | 1 | 6 | 6 | 9 | 4 | 36 |

*The Unguided group had a mean of 47.40 and a standard deviation of 6.80.

APPENDIX E

Summary of Individual Records of Unguided Group (Concl.)

| Unguided Subject | Total Moves | Total Time on Trials | Mean Time per Move 3 | 4 | 5 | 6 | 7 | all |
|---|---|---|---|---|---|---|---|---|
| 1 | 1061 | 4290 | 2.5 | 3.9 | 4.1 | 5.2 | 2.6 | 4.0 |
| 2 | 868 | 4295 | 5.1 | 4.9 | 4.6 | 5.7 | 5.0 | 5.0 |
| 3 | 950 | 5019 | 4.3 | 3.6 | 5.5 | 5.1 | 5.5 | 5.3 |
| 4 | 1318 | 4114 | 3.2 | 4.0 | 2.8 | 3.3 | 2.9 | 3.1 |
| 5 | 1921 | 7097 | 4.2 | 4.9 | 3.8 | 2.9 | 3.0 | 3.7 |
| 6 | 1529 | 6967 | 3.7 | 5.6 | 4.4 | 4.4 | 4.4 | 4.6 |
| 7 | 1678 | 8629 | 11.4 | 4.5 | 5.4 | 5.3 | 3.4 | 5.1 |
| 8 | 2620 | 9082 | 6.5 | 6.2 | 5.0 | 3.5 | 2.3 | 3.5 |
| 9 | 896 | 3058 | 3.1 | 3.1 | 3.2 | 3.3 | 3.7 | 3.4 |
| 10 | 768 | 3064 | 2.1 | 3.6 | 5.2 | 4.6 | 3.7 | 4.0 |
| 11 | 2057 | 7122 | 4.6 | 5.7 | 4.0 | 3.3 | 2.3 | 3.5 |
| 12 | 1187 | 8563 | 8.0 | 12.1 | 13.0 | 6.1 | 3.8 | 7.2 |
| 13 | 2570 | 10281 | 4.8 | 5.5 | 5.1 | 4.5 | 3.2 | 4.0 |
| 14 | 1460 | 4622 | 6.5 | 6.6 | 3.5 | 2.5 | 2.2 | 3.2 |
| 15 | 1607 | 7040 | 2.6 | 5.2 | 4.8 | 4.4 | 3.6 | 4.4 |
| 16 | 844 | 3442 | 3.7 | 6.4 | 6.0 | 5.0 | 3.3 | 4.1 |
| 17 | 697 | 3365 | 8.0 | 9.9 | 4.2 | 5.1 | 3.0 | 4.8 |
| 18 | 2509 | 11056 | 6.6 | 8.3 | 6.4 | 4.1 | 3.1 | 4.4 |
| 19 | 6437 | 30657 | 4.0 | 4.1 | 3.6 | 3.3 | 6.0 | 4.8 |
| 20 | 2223 | 10250 | 5.5 | 7.8 | 3.8 | 5.6 | 3.1 | 4.6 |

APPENDIX F

Summary of Individual Records of Guided Group

| Guided Subject | A.E.D.* Score | Errors on Questions | Extra Trials on Discs 3 | 4 | 5 | 6 | 7 | all |
|---|---|---|---|---|---|---|---|---|
| 1 | 39 | 6 | 1 | 1 | 0 | 0 | 0 | 2 |
| 2 | 59 | 7 | 1 | 0 | 2 | 0 | 0 | 3 |
| 3 | 44 | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| 4 | 39 | 8 | 1 | 0 | 1 | 0 | 0 | 2 |
| 5 | 40 | 11 | 3 | 1 | 1 | 2 | 0 | 7 |
| 6 | 55 | 1 | 0 | 0 | 0 | 0 | 1 | 1 |
| 7 | 60 | 2 | 1 | 0 | 0 | 1 | 0 | 2 |
| 8 | 48 | 5 | 0 | 0 | 1 | 0 | 0 | 1 |
| 9 | 52 | 3 | 0 | 1 | 0 | 0 | 0 | 1 |
| 10 | 43 | 3 | 1 | 1 | 1 | 0 | 0 | 3 |
| 11 | 58 | 7 | 1 | 4 | 4 | 0 | 0 | 9 |
| 12 | 53 | 4 | 0 | 2 | 1 | 0 | 0 | 3 |
| 13 | 51 | 4 | 0 | 0 | 1 | 0 | 0 | 1 |
| 14 | 53 | 4 | 0 | 1 | 2 | 0 | 0 | 3 |
| 15 | 60 | 3 | 0 | 0 | 0 | 1 | 0 | 1 |
| 16 | 42 | 10 | 1 | 0 | 5 | 2 | 1 | 9 |
| 17 | 48 | 6 | 0 | 3 | 0 | 1 | 0 | 4 |
| 18 | 25 | 7 | 0 | 2 | 2 | 0 | 0 | 4 |
| 19 | 34 | 5 | 1 | 0 | 0 | 0 | 0 | 1 |
| 20 | 44 | 15 | 1 | 1 | 3 | 1 | 0 | 6 |

*The Guided group had a mean of 47.35 and standard deviation of 9.37.

APPENDIX F

Summary of Individual Records of Guided Group (Concl.)

| Guided Subject | Total Moves | Total Time on Trials | Mean Time per Move 3 | 4 | 5 | 6 | 7 | all |
|---|---|---|---|---|---|---|---|---|
| 1 | 512 | 1942 | 2.4 | 7.4 | 4.3 | 3.3 | 3.4 | 3.8 |
| 2 | 559 | 1515 | 3.7 | 3.0 | 2.3 | 3.7 | 2.3 | 2.7 |
| 3 | 550 | 1133 | 1.7 | 2.1 | 2.4 | 2.4 | 1.7 | 2.1 |
| 4 | 530 | 1890 | 4.4 | 4.4 | 3.7 | 3.5 | 3.4 | 3.6 |
| 5 | 822 | 3877 | 1.7 | 5.6 | 7.7 | 4.9 | 4.1 | 4.7 |
| 6 | 615 | 1561 | 2.7 | 5.0 | 5.1 | 2.2 | 2.0 | 2.5 |
| 7 | 615 | 1771 | 12.3 | 5.7 | 3.8 | 3.9 | 1.8 | 2.9 |
| 8 | 523 | 1693 | 2.9 | 5.3 | 4.7 | 2.8 | 2.7 | 3.2 |
| 9 | 503 | 1761 | 5.9 | 5.5 | 4.3 | 3.6 | 2.7 | 3.5 |
| 10 | 545 | 1619 | 4.8 | 3.1 | 3.1 | 3.5 | 2.5 | 3.0 |
| 11 | 696 | 2356 | 5.5 | 4.4 | 3.5 | 2.8 | 3.0 | 3.4 |
| 12 | 550 | 2140 | 8.4 | 5.1 | 5.1 | 3.5 | 3.1 | 3.9 |
| 13 | 519 | 1969 | 4.1 | 7.4 | 6.2 | 3.6 | 2.6 | 3.8 |
| 14 | 566 | 2058 | 4.4 | 7.2 | 4.9 | 3.2 | 2.6 | 3.6 |
| 15 | 550 | 1495 | 2.9 | 5.5 | 4.1 | 2.6 | 2.1 | 2.7 |
| 16 | 938 | 2473 | 4.9 | 2.7 | 3.0 | 2.3 | 2.5 | 2.6 |
| 17 | 598 | 2446 | 6.7 | 5.9 | 4.2 | 4.0 | 3.4 | 4.1 |
| 18 | 583 | 1630 | 3.3 | 3.9 | 3.2 | 3.0 | 2.2 | 2.8 |
| 19 | 496 | 2169 | 9.3 | 5.9 | 7.9 | 4.6 | 2.8 | 4.4 |
| 20 | 678 | 2430 | 7.9 | 4.7 | 5.3 | 2.4 | 2.8 | 3.6 |

# CHARACTER OF ANALYSIS AND GENERALIZATION AS AFFECTED BY INITIAL INSTRUCTIONS IN PROBLEM SOLVING

by

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An investigation was made to study the effects of tuition, given in the form of initial instructions, on human learning. An experiment was designed in which 40 college level adults were divided into two groups which were designated the Guided group and the Unguided group. The two groups were of equal ability as measured by the A.E.D. test of Verbal Aptitude. Both groups solved the disc transfer problem beginning with 3 discs. Subjects were required to work on the problem until they attained the criterion which was two successive correct trials. The number of discs was successively increased up to a total of 7 discs, subjects having been required to attain the criterion before passing to the next highest number of discs. The Unguided group was informed as to the goal to be reached and instructed to move only 1 disc at a time and not to place a larger disc upon a smaller one. The Guided group was given the same instructions, but was, in addition, told to move the smallest disc first and every second time thereafter in the direction indicated by an arrow which pointed clockwise for odd numbers of discs and counter clockwise for even numbers of discs. The time for trials was recorded in addition to a qualitative description of all moves.

Upon successful completion of the 7 discs problem, subjects were given 22 problem questions which were designed to measure abilities of the two groups to generalize at abstract levels, to perceive relations, and to use these relations in dealing with new material.

Differences, significant at the 1 per cent level of confidence, were found for extra trials, time on trials, and total moves for performances on 4, 5, and 6 discs. No significant differences were found for performances on the lowest and highest numbers of discs, that is, on 3 and 7 discs. It was suggested that the lack of a difference for 3 discs was due to the two tasks being of approximately equal difficulty. The tasks for the Unguided group became much more difficult as more discs were added. Upon reaching the problem involving the transfer of 7 discs, however, the Unguided group had learned the principles required to make correct disc transfers and thus tended to equal the Guided group. Guidance was found to reduce variability, as measured by standard deviations and coefficients of variation, in performances on the disc transfer problems.

On the problem questions the Guided group made a total of 111 errors as compared with 75 errors for the Unguided group, a difference significant at the 6 per cent level of confidence. As measured by the problem questions, guided subjects were less able to generalize, to apply their peg board experience to new material, and to analyze relationships. The performances of the guided subjects showed greater variability than did those of the unguided. It was concluded that guidance was efficacious in its influence on the solution of the disc transfer problems but that it adversely influenced transfer, the perception of relations, and the use of these relations in dealing with new material.